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(54) Magnetron sputtering apparatus

Magnetronzerstäubungsanlage

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(56) References cited:
EP-A- 0 504 477
FR-A- 2 568 269
US-A- 4 362 611
WO-A-94/16118
GB-A- 2 109 010

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Description

[0001] This invention relates generally to magnetrons of a type using rotating cylindrical sputtering targets, and, more specifically, to structures and techniques for minimising arcing in such magnetrons.

[0002] Cylindrical magnetrons are becoming widely used for depositing films on substrates. An example is the deposition of a stack of dielectric and metal layers on a surface of a glass substrate for the purpose of filtering out a portion of solar energy from passing through the glass. Such a substrate is positioned within a vacuum chamber containing at least one, and usually two, rotating cylindrical targets containing sputtering material on an outer surface thereof. Both inert and reactive gases are generally introduced into the chamber. A voltage applied to the sputtering target, with respect to either the vacuum chamber enclosure or a separate anode, creates a plasma that is localised along a sputtering zone of the target by stationary magnets positioned within the target. Material is sputtered off the target surface and on to the substrate by bombarding the target with electrons and ions of the plasma as it passes through the stationary sputtering zone.

[0003] The magnets are usually of a permanent magnet type, arranged along a line within the rotating cylindrical target and held against rotation with the target. The sputtering zone is created by the magnets along substantially the entire length of the cylindrical sputtering target and extends only a small circumferential (radial) distance around it. Traditionally, the magnets are arranged so that the sputtering zone exists at the bottom of the cylindrical target, facing a substrate being coated directly beneath.

[0004] Although deposition of the film is desired to take place only on the substrate, it is also deposited on other surfaces within the reactive chamber. This can create a problem in many situations, especially when certain dielectrics are being deposited as the film. For example, if the target surface is silicon and the reactive gas is oxygen, silicon or aluminium oxides are deposited on the target surface, surfaces of target supporting structures, and the like, as well as on.the substrate that is intended to be coated. After a certain build-up of dielectric material on internal vacuum chamber surfaces has occurred over time, arcing to those surfaces can begin. Arcing is undesirable since it generates particles that contaminate the film being deposited on the substrate, and overloads the power supply that creates the plasma through an electrical connection with the sputtering target surface and the vacuum chamber walls or some other anode.

[0005] An advantage of a rotating cylindrical sputtering target is that such a film deposited on the target is subjected to being sputtered away as the target surface passes through the sputtering zone, thus counteracting the undesirable film build-up. Despite this self-cleaning characteristic, however, undesirable arcing can still occur in rotary magnetrons under certain circumstances.

[0006] A cylindrical magnetron shield structure has been developed to minimise this undesirable arcing that occurs in rotary cylindrical magnetrons as described in US Patent No. 5,108,574. As shown in this US patent, the deposition of dielectric film can be minimised by dark space shielding, which prevents plasma formation in the dark space and thereby reduces film deposition and subsequent arcing.

[0007] Although the shield structure of this prior US patent greatly enhances the self-cleaning characteristics of rotary cylindrical magnetrons, some deposition of condensate has been found to occur at the far ends of the target cylinder. Unlike the deposition of dielectric films described in this US patent, this deposition of condensate from the vapour present in the system occurs regardless of the existence of plasma. Thus, the problem of condensate deposition is not fully resolved by the use of dark space shielding.

[0008] Recently, a cylindrical magnetron shield structure has been developed to minimise the occurrence of such condensation deposition and related arcing at the ends of the target cylinder - see US Patent No. 5,464,518. In particular, the shield structure is shaped at its inner edges to conform substantially to a pattern of condensation that results when the magnetron is operated with the target held stationary. The shaped shield structure is positioned with respect to the target to shield regions where condensation of vaporised material would otherwise occur at a rate which exceeds the rate at which deposited condensate is removed from the target by sputtering. Use of such a shaped shield structure can greatly reduce condensate deposition at the ends of the target and related arcing activity.

[0009] However, even slight deposition of dielectric or insulating material at the ends of the target may result in undesirable arcing activity. Generally, when the condensate build-up approaches ground or vacuum chamber potential, arcs to the condensate surface appear to travel across the condensate surface toward the vacuum chamber wall or other anode.

[0010] Additionally, prior rotatable magnetrons have been configured such that the shield structure is at ground (earthed), vacuum chamber potential or cathode potential. In these magnetrons, the shield structure has proven to be a site of preferential arcing from the cathode to the vacuum chamber wall or other anode.

[0011] The present invention is concerned with the provision of a mechanism and technique for minimising such undesirable arcing activity.

[0012] In accordance with the invention, there is provided an apparatus for depositing, in a gaseous atmosphere within a vacuum chamber, a film onto a substrate by sputtering material from a cylindrically shaped target that is rotatably carried at opposite ends thereof by respective support blocks, the target containing magnets non-rotatably held therein in order to establish a sputtering zone extending along a length of the target, the

apparatus including an electrical power supply in electrical communication with said target, and the apparatus including at least one cylindrically shaped shield structure carried by at least one of the support blocks and extending over at least one associated end of the target with a space therebetween, wherein the shield structure comprises at least one annular structure extending around an outside surface thereof, the at least one annular structure being dimensioned to interrupt movement of any arc which might otherwise travel across the outside surface.

[0013] In the present invention in general a cylindrical shield structure is provided which has an annular structure extending around its outside surface, wherein the annular structure is dimensioned to interrupt movement of any arc which might otherwise travel across its outside surface. In a preferred form, the shield structure is electrically isolated from ground, vacuum chamber or other anode potential.

[0014] In a cylindrical rotatable magnetron system, it is apparent that arcing occurs between the cathodic target and an anode of the system. Particularly, it has become apparent that condensate build-up at the ends of the target often approaches or reaches ground, vacuum chamber or anodic potential and thus, potentiates severe arcs which travel across the condensate surface. In situations where the condensate build-up contacts the shield structure such that the shield structure becomes an anode, arcs travelling across the shield structure are particularly severe because of the close proximity of the shield structure and the cathode.

[0015] The shield structure of the invention serves to suppress the movement of any such arcs that might otherwise travel across the outside surface of the shield structure toward the vacuum chamber walls or other anode. Generally, the shield structure comprises at least one annular structure extending around its outside surface. Preferably, a width of the annular structure is greater than a width of an arc, so that the arc is sufficiently disrupted and prevented from circumventing the wider annular structure. Additionally, the annular structure width is preferably less than one-half of a mean free path of the gas within the vacuum chamber, a dimension too small to permit collision of the gaseous molecules, so that the plasma is sufficiently disrupted by the annular structure. In this manner, the annular structure may act as a dark space which traps the arc and thereby interrupts its otherwise natural movement across the shield structure.

[0016] Preferably, the annular structure extends radially with respect to the outside surface of the shield structure. The radial extent of the annular structure is preferably greater than the annular structure width, so that an arc travelling across the surface of the shield structure encounters a sufficiently abrupt surface transition, or a sufficient obstacle to arc movement. While the annular structure may take a variety of forms, preferably it is a groove having the above-described dimensions, which is indented with respect to the outside surface of the shield structure.

[0017] As summarised above, because of the proximity of the shield structure and the cathode, arcing is particularly severe when the shield structure becomes an anode. Thus, preferably, the shield structure is electrically isolated from ground, vacuum chamber or other anode potential. Particularly in situations where the condensate build-up fills the shield structure or contacts the target from the shield structure, the electrically isolated, or floating, shield structure is prevented from becoming an anode.

[0018] The invention can thus reduce arcing by minimising the size or extent of movement of any arcs which might occur. The invention can further reduce the severity of any such arcing activity and the damage caused thereby.

[0019] For a better understanding of the invention, reference will now be made, by way of exemplification only, to the accompanying drawings in which:

Figure 1 schematically illustrates a cylindrical sputtering target magnetron, including the improvement of the invention;

Figure 2 shows a cross-section of a portion of a target assembly of Figure 1, including the improvement of the invention;

Figure 3 shows in isometric view a portion of a target assembly of Figure 1, in disassembly, including the improvement of the invention;

Figure 4 is a cross-section of a portion of a cylindrical shield structure, including the improvement of the invention;

Figure 5 is a cross-section of a portion of a cylindrical shield structure, including an alternative embodiment of the improvement of the invention;

Figure 6 is a cross-section of a portion of a cylindrical shield structure, including another alternative embodiment of the improvement of the invention;

Figure 7 is a cross-section of a portion of a cylindrical shield structure, including another alternative embodiment of the improvement of the invention; and

Figure 8 is an illustration of an arc pattern, as observed on the support block and the target of a previous cylindrical sputtering target magnetron, showing an "arc-width" which is used to define, in part, the improvement of the invention.

[0020] In Figure 1, a representative configuration of a standard cylindrical rotatable magnetron system 10 is

shown. A box 12, shown in dotted outline, indicates metallic walls of a vacuum chamber in which the sputtering occurs. Within the vacuum chamber is a rotatable cylindrical target structure 14 which is held by the frame 12 via support blocks 16 and 18 in a manner to be rotatable about its longitudinal axis 20.

[0021] Although one target structure is shown in Figure 1, in many applications two or more such targets may be used.

[0022] The magnetron 10 of Figure 1 is shown to have a substrate 22, which is typically supported by some kind of support structure (not shown). For example, the support structure may comprise rollers to allow the substrate 22 to be passed through the vacuum chamber 12 in a continuous process. A vacuum is drawn within the vacuum chamber by an appropriate pumping system 24. One or more gases are provided by a supply 26 to the vacuum chamber by some convenient delivery system, such as a perforated tube (not shown) positioned across the vacuum chamber. The particular gases utilised depend primarily upon the film desired to be deposited on the substrate 22.

[0023] A cylindrical section 28 of sputtering material is provided as part of the target structure 14. The sputtering material is selected according to the intended composition of the film to be deposited on the substrate 22. An electric motor source (not shown), positioned outside the vacuum chamber, rotates the target structure 14. This target rotation may be facilitated by rotating a spindle 32 or 34 (see spindle 34 of Figure 2, for example) which is in contact the target 14, as is known in the art.

[0024] A plasma is created within the vacuum chamber by applying a voltage from a power supply 36 to the sputtering surface 28 which is negative with respect to the vacuum chamber walls 12, the support blocks 16 and 18 or some other anode, which is usually connected to ground potential. As shown in Figure 1, the power supply 36 is in electrical communication with the target 14, being connected thereto through an anode within the vacuum chamber, such as support block 18. The plasma is positioned adjacent a sputtering zone of the cylindrical sputtering target 14, as controlled by the positioning of magnets (not shown).

[0025] These magnets are positioned along the length of the cylindrical sputtering target 14, while extending a small circumferential, or radial, distance therearound. The magnets are most conveniently held within the sputtering target 14 by attachment to a coolant conduit (not shown). The coolant conduit is provided as part of the target structure 14 in a manner to be rotatable independently of the rotation of the target structure, as is known in the art. Thus, the position of the magnets in the target structure 14 and the consequent position of the sputtering zone, is controlled by rotation of the coolant conduit. In operation, the magnets are non-rotatably held within the target 14 to establish a stationary sputtering zone extending along a length of the target. In Figure 1, an oblong 30, shown in dotted outline, generally represents the position of the magnets which defines the sputtering zone.

[0026] A cooling liquid supply and exhaust system (not shown) outside the vacuum chamber provides coolant into the conduit and exhausts the heated coolant from a space between the outside of the conduit and an interior surface of the spindle 32 or 34, as is known in the art. An electrical and electronic control system (not shown) operates to control the various parameters of the magnetron system being described. The cylindrical rotatable magnetron system in which the shield structure of the invention is used may be operated under various operating conditions, including high current conditions, upwards of 100 amps.

[0027] The improvement of the invention is implemented in the system of Figure 1 by providing at least one cylindrically shaped shield structure (shown as 38 and 40 in Figure 1) around and spaced from the cylindrical target surface. The details of the improvement are described following a description of the general form of the cylindrically shaped shield structure.

[0028] The cylindrical shield structure may take the general form of the unified shield structure described in US Patent No. 5,108,574. Preferably, the unified shield embodiment of the present invention takes the form of the shaped unified shield described in Sieck et al. When the shield structure of the present invention is in a unified shield form, the unified shield structure may be carried by one of the support blocks 16 and 18 of Figure 1, but preferably, is carried by both support blocks.

[0029] This cylindrically shaped unified shield extends around a portion of a circumference of the target that is substantially outside of the sputtering zone, so that this non-sputtering portion of the target is shielded. Additionally, the unified shield structure has an opening which is at least as large as the sputtering zone. This opening, which does not extend to the full length of the shield, extends around a portion of the circumference of the target that is substantially inside the sputtering zone, so that the sputtering portion of the target is exposed.

[0030] Alternatively, the shield structure may take the general form of two separate shield structures, as described in US Patent No. 5,213,672, the contents of which are incorporated herein by reference. Preferably, the dual shield structure embodiment of the invention takes the form of the two shaped shield structures described US Patent No. 5,464,518. When the shield structure is in the dual shield form, as shown in Figure 1, a first shield structure 38 is carried by support block 16, while a second shield structure 40 is carried by support block 18.

[0031] The preferred, shaped form of the unified shield or dual shield embodiments of the shield structure is now described. Particularly, the unified shield opening, which leaves the sputtering zone exposed, is shaped to conform substantially to a shape of a pattern of condensation of vaporised material that forms when

the target is held stationary. The unified shield thus shields regions where condensation of vaporised material might otherwise occur at a rate at which deposited condensate is removed from the target by sputtering. In the dual shield embodiment, the first and second shields are shaped as described above and positioned to shield the above-described regions.

[0032] Thus, in the preferred, shaped form, the shield structure exposes an operationally defined effective sputtering zone, while shielding regions of the target where condensation might otherwise occur. By shielding these defined regions, the preferred shaped shield structure minimises the formation of undesirable condensation at the end portions of a cylindrical sputtering target assembly and thereby; reduces the often catastrophic arcing that results therefrom.

[0033] Whether the shield structure takes the unified shield or dual shield form, at least one shield structure extends over at least one end of the opposite ends 42 and 44 of the target structure 14 that is associated therewith. For example, as shown in Figure 1, shield 38 and opposite shield 40 respectively extend over end 42 and opposite end 44 of the target. Additionally, the shield structure may extend in length beyond the end of the sputtering material in order to cover exposed surfaces of an adjacent spindle and its supporting structure. For example, as shown in Figure 2, shield 40 covers the exposed surfaces of spindle 34.

[0034] It will be noted from Figures 1 and 2 that an annular space 50 exists between an outside surface of the target 14 and an inside surface of the cylindrically shaped shield structure. The radial size of annular space 50 is selected to avoid plasma formation between these two surfaces. The radial size of the annular space 50 is typically significantly less than one inch and preferably, less than substantially one-quarter of an inch, for example, one-eighth of an inch.

[0035] The invention is now described with respect to the dual shield embodiment shown in Figure 1-3, wherein shields 38 and 40 are shown to have the preferred, shaped portions 46 and 48, respectively, and in terms of the particular features shown in Figures 4-8. While the invention is described in terms of the preferred, shaped form of the dual shield embodiment, aspects of the invention described herein are equally applicable in the unified shield and other embodiments described herein.

[0036] According to the improvement of the present invention, the shields 38 and 40 have at least one annular structure 52 extending around their outside surfaces. The annular structure 52 is designed to suppress or interrupt movement of any arc which might otherwise travel across the outside surface of the shield structure.

[0037] In particular, in a cylindrical rotatable magnetron system, it is apparent that arcing occurs between the cathodic target and an anode of the system; evidence of arcing activity has been observed in such a system, in the form of an arc pattern on the target ends and the support blocks. As illustrated in Figure 8, the arc pattern may consist of several arc tracings 54, representative of arcs, which appear to travel in a lightning-bolt manner across the surface of the support block 58 and the target end 60 of such a system. The arc tracings 54 indicate that the arcs tend to travel annularly (with respect to longitudinal axis 20) around these surfaces. The arc tracings 54 further show the arcs to have a primary arc 56, travelling in a certain direction, and multiple branches, branching from the primary arc and travelling in substantially the direction of the primary arc. For convenience, the arc pattern will be described herein in terms of the primary arc 56 and the arc-width D thereof, as opposed to the arc tracings 54 and the branch-width E thereof.

[0038] It is believed that the arcing activity observed in previous cylindrical rotatable magnetron systems results from condensate build-up at the ends of the target. As the condensate build-up approaches or reaches ground (earthed), vacuum chamber or anodic potential, arcs to the condensate surface appear to travel across the condensate surface toward the ground source, vacuum chamber wall or other anode. Such arcing activity causes significant damage to the target structure and the support blocks, as illustrated in Figure 8, and other system structures over which the arcs travel.

[0039] Shields 38 and 40 are used to minimise condensate build-up and thus, to reduce the potential for, and the extent of, any such arcing activity. Further, these shields are designed with annular structures 52 to suppress or interrupt movement of any arc which might otherwise travel across the outside surface of the shield structure. In this latter respect, the shield structure of the invention is effective in the suppression of arcs which are particularly severe, given the close proximity of the cathodic target 14 and the shield structure.

[0040] According to the invention, the annular structure 52 of the shield 38 or 40 is generally a full or partial ring, which is annularly disposed with respect to longitudinal axis 20 and radially extended with respect to the outside surface 62 of the shield 38 or 40. By way of example, as shown in Figures 1-3, shields 38 and 40 may have three annular structures 52, one of which is a partial ring, accommodating the shaped portion 46 and 48 of the respective shields, and the remaining two of which are full rings.

[0041] The annular structure 52 may take a variety of forms. For example, as shown in Figures 6 and 7, the annular structure 52 may be substantially triangular in shape, having a width B" or B"' which forms the base of a triangle and a radial extension C" or C"' which forms the altitude of the triangle. Preferably, the annular structure 52 is substantially rectangular in shape, as shown in Figures 4 and 5, having a width B or B' and a radial extension C or C' which form adjacent sides of a rectangle.

[0042] As shown in Figures 5 and 7, the annular structure 52 may take the form of a ridge, such that the an-

nular structure radial extension C' or C''' is directed outwardly with respect to the outside surface 62 of the shield structure. Preferably, the annular structure 52 is in the form of a groove, as shown in Figures 4 and 6, such that the annular structure radial extension C or C" is directed inwardly with respect to the outside surface 62 of the shield structure. In the latter form, the groove may actually trap an arc and thereby, prevent its further travel across the outside surface 62 of the shield structure.

[0043] According to the invention, the annular structure 52 may be particularly dimensioned to achieve arc suppression. Generally, the dimensions of the annular structure 52 are such that any arc, such as arc 56 of Figure 8, which might be generated within the vacuum chamber and thus, potentially encounter the annular structure, is sufficiently disrupted and obstructed in its travel path by the annular structure. Thus, the annular structure 52 should be of sufficient width and radial extension to interrupt or obstruct the travel path of the arc. Preferably, however, the annular structure 52 should not be wide enough to support plasma formation in its vicinity.

[0044] More particularly, the annular structure 52 may be specifically dimensioned in terms of width and radial extension, as shown in Figures 4-7 and defined in terms of the arc-width D of Figure 8. An approach to, or beginning of, the annular structure 52 has a width A, A', A" or A''', which need not be, but typically is greater than a width B, B', B" or B''', respectively, of the annular structure. The approach may be rounded, sanded or filed to prevent injury in the handling of the shield structure 52. Preferably, however, the approach is not too smooth, but rather fairly abrupt, to ensure that the arc is sufficiently interrupted.

[0045] In a preferred embodiment, the annular structure 52 has a width B, B', B" or B''' that is less is than one-half of a mean free path of the gas within the vacuum chamber. Preferably, the annular structure width B, B', B" or B''' is also greater than a width D of an arc which might otherwise travel across the outside surfaces of the shields 38 and 40. As shown in Figure 8, an arc-width D may be approximated by the width D of a burn spot of a primary arc 56, observed in an arc tracing 54 on a surface within a cylindrical rotatable magnetron system. Additionally, the annular structure preferably has a radial extension C, C', C" or C''' that is greater than its respective width B, B', B" or B'''.

[0046] In the preferred grooved embodiments of Figures 4 and 6, the annular structure 52 is thus wide enough to capture an arc in the groove and deep enough to trap the captured arc. However, the annular structure 52 is also sufficiently narrow such that plasma formation in the groove and its vicinity is minimised. Particularly, as the groove width B or B^2 is less than one-half of the mean free path of the gas, the annular groove 52 reduces the potential for, or number of, collisions between gaseous molecules and thus, minimises or eliminates plasma formation in the groove and its vicinity.

[0047] Thus, when the annular structure 52 is in the preferred form of a groove, it acts as a both an arc-trap and a dark space. The groove is preferably flat-bottomed, as shown in Figure 4, so that any trapped arc rests in the groove. In this manner, the annular groove traps the arc, interrupting its otherwise natural movement across the shield structure, and further inhibits its ability to escape the trap.

[0048] In addition to the dimensional aspects described above, the annular structure 52 should have dimensions that are conveniently machinable. The annular structure width B, B', B" or B''' may be greater than or equal to about 0.005 of an inch, which is the approximate arc-width D of an arc 56 evidenced in a cylindrical rotatable magnetron system. Alternatively, the annular structure width B, B', B" or B''' may be greater than or equal to about 0.01 of an inch, which is the approximate arc-width D of another arc 56 evidenced in a cylindrical rotatable magnetron system.

[0049] Furthermore, the annular structure width B, B', B" or B''' may be less than or equal to about one-eighth of an inch or, alternatively, less than or equal to about one-sixteenth of an inch. Each of these alternative annular structure widths represents one-half of a typical mean free path distance operative in a cylindrical rotatable magnetron system. As is known in the art, the mean free path of a gas within the vacuum chamber 12 depends on various operational parameters, including pressure, temperature and the composition of the gas.

[0050] It has been found that a shield structure placed between the target and a ground source or other anode can become anodic during the operation of a cylindrical rotatable magnetron system. Because of the close proximity of the shield structure and the cathodic target, such anodic behaviour results in severe arcs which travel from the cathodic target, across the anodic shield structure and toward a ground source or other anode, such as the support block or vacuum chamber. While some systems employ an insulator between the shield structure and the support block, these severe arcs travelling across the anodic shield surface often jump across the insulator surface to the support block or other anode.

[0051] Thus, in a preferred embodiment of the invention, the shield structure is electrically isolated from ground, vacuum chamber or other anode potential. This electrical isolation inhibits the ability of the shield structure to approach or reach ground or anodic potential. Rather, the shield structure is allowed to float between cathodic and anodic potential.

[0052] In this manner, the electrically isolated shield structure inhibits the formation of severe arcs between it and the cathodic target 14. Further, with its arc-suppressing annular structure 52, the shield structure of the invention inhibits movement of an arc which might otherwise travel across its surface toward the support blocks 16 and 18 or vacuum chamber 12.

[0053] The electrically isolated shield structure is now

described with reference to Figures 1-3. As schematically shown in Figure 1, the electrical power supply 36 controls the potential of the cathodic target 14 by way of its connection thereto through the anodic or ground support block 18. The vacuum chamber 12 and support block 16 are also shown at ground potential. The shields 38 and 40 are shown to be free of any direct voltage control.

[0054] As shown in the assembly of Figure 2, the shield 40 is not physically connected to the cathodic target 14. Additionally, the shield 40 is separated from the ground or anodic support block 18 by an insulator 64. The insulator 64 is typically about three-eighths of an inch thick and thus, the separation distance between the shield and the support block 18 may also be about three-eighths of an inch. While physically separated from support block 18, the shield 40 is indirectly supported thereby by a screw 66, bolt or equivalent means which secures the shield and the insulator to the support block 18.

[0055] A similar configuration is shown in disassembly in Figure 3. In this configuration, support block 16, insulator 64 and shield 38 are equipped with apertures 68 which accommodate a screw-type, bolt-type or other equivalent assembly. By way of example, screws 70 are used to affix insulator 64 to support block 16 through accommodating, corresponding screw-type apertures 68¢ in the insulator and the support block. Similarly, screws 72 are used to affix the shield 38 to the insulator 64 and/or the support block 16 through accommodating, corresponding screw-type apertures 68^2 in the shield, the insulator and/or the support block. Other accommodating structures, such as sleeves placed between the shield structure and the target tube to accommodate various shield or target tube sizes, can be employed in the assembly of the cylindrical rotatable magnetron system.

[0056] The shield structure of the invention generally can reduce arcing activity in cylindrical rotatable magnetron systems by inhibiting the propagation of any arcs which might otherwise travel across the shield structure toward a ground source or other anode.

Claims

1. Apparatus (10) for depositing, in a gaseous atmosphere within a vacuum chamber, a film on to a substrate (22) by sputtering material from a cylindrically shaped target (14) that is rotatably carried at opposite ends (42,44) thereof by respective support blocks (16,18), the target containing magnets non-rotatably held therein in order to establish a sputtering zone extending along a length of the target, the apparatus including an electrical power supply (36) in electrical communication with the target, and the apparatus including at least one cylindrically shaped shield structure (38 and/or 40) carried by at least one of the support blocks and extending over at least one associated end of the target with a space (50) therebetween, **characterised in that** the shield structure comprises at least one annular structure (52) extending around an outside surface (62) thereof, and being dimensioned to interrupt movement of any arc (56) which might otherwise travel across the outside surface.

2. Apparatus according to Claim 1 in which the annular structure is dimensioned to interrupt plasma formation which might otherwise occur in a vicinity of the annular structure.

3. Apparatus according to Claim 1 or Claim 2 in which the at least one annular structure has a width (B, B', B" or B"') that is less than one-half a mean free path of the gas within the vacuum chamber and greater than a width (D) of the arc, the annular structure additionally being radially extended with respect to the outside surface, such that a radial extension (C, C', C" or C"') thereof is greater than the annular structure width.

4. Apparatus according to Claim 3 in which the annular structure is substantially rectangular in shape, the annular structure width (B or B') and the radial extension (C or C') forming adjacent sides of a rectangle.

5. Apparatus according to Claim 3 in which the annular structure is substantially triangular in shape, the annular structure width (B" or B"')forming a base of a triangle and the radial extension (C" or C"') forming an altitude of the triangle.

6. Apparatus according to any one of Claims 3, 4 or 5 in which the annular structure is a groove, the radial extension (C or C") being directed inwardly with respect to the outside surface.

7. Apparatus according to any one of Claims 3, 4 or 5 in which the annular structure is a ridge, the radial extension (C' or C"') being directed outwardly with respect to the outside surface.

8. Apparatus according to Claim 1 in which the shield structure is electrically isolated from ground potential or a potential of the at least one support block.

9. Apparatus according to any preceding claim in which the at least one cylindrically shaped shield structure comprises a cylindrically shaped unified shield carried by each of the support blocks, the unified shield extending around a portion of a circumference of the target that is substantially outside the sputtering zone and having an opening at least as large as the sputtering zone, the opening extending

around another portion of the circumference that is substantially inside the sputtering zone and having a length less than a distance between the opposite ends of the target.

10. Apparatus according to Claim 1 in which the at least one cylindrically shaped shield structure comprises first and second cylindrical shields (38 and 40) respectively carried by a first and second support block of the support blocks.

11. A method of depositing, in an apparatus having a vacuum chamber and a gaseous atmosphere therein, a dielectric or an insulating film onto a substrate by sputtering material from a cylindrically shaped target (14) that is rotatably carried at opposite ends (42,44) thereof by respective support blocks (16,18), the target containing magnets non-rotatably held therein in order to establish a sputtering zone extending along a length of the target, the apparatus (10) including an electrical power supply (36) in electrical communication with the target, and the apparatus including at least one cylindrically shaped shield structure (38 and/or 40) carried by at least one of the support blocks and extending over at least one associated end of the target with a space (50) therebetween, **characterised in that** the method includes a step of interrupting movement of any arc (56) which might otherwise travel across an outside surface (62) of the shield, structure, by use of at least one annular structure (52), extending around the outside surface and dimensioned to interrupt the movement.

Patentansprüche

1. Einrichtung (10) zum Aufbringen eines Film auf ein Substrat (22) in einer gasförmigen Atmosphäre innerhalb einer Vakuumkammer durch Zerstäuben von Material von einem Target (14) mit zylindrischer Form, das an seinen entgegengesetzten Enden (42, 44) jeweils durch einen Lagerblock (16, 18) drehbar gelagert ist und darin nicht drehbare Magnete enthält, um eine Zerstäubungszone herzustellen, die sich entlang der Targetlänge erstreckt, wobei die Einrichtung eine elektrische Energiequelle (36) in elektrischer Verbindung mit dem Target sowie mindestens eine zylindrisch geformte Abschirmkonstruktion (38 und/oder 40) aufweist, die von mindestens einem der Lagerblöcke getragen wird und sich über mindestens das zugehörige Ende des Targets unter Bildung eines Zwischenraums (50) dazwischen erstreckt, **dadurch gekennzeichnet, dass** die Abschirmkonstruktion mindestens ein ringförmiges Gebilde (52) aufweist, der um einen Außenfläche (62) der Abschirmkonstruktion verläuft und so dimensioniert ist, dass er die Bewegung irgendeines Lichtbogens (56) unterbricht, der sonst über die Außenfläche wandern könnte.

2. Einrichtung nach Anspruch 1, wobei das ringförmige Gebilde so dimensioniert ist, dass er eine Plasmabildung unterbricht, die sonst in der Nähe des Ringgebildes auftreten könnte.

3. Einrichtung nach Anspruch 1 oder 2, wobei das mindestens eine ringförmiges Gebilde eine Breite (B, B', B", oder B"') aufweist, die weniger als die Hälfte einer mittleren freien Gasstrecke in der Vakuumkammer und größer als eine Lichtbogenbreite (D) ist, und wobei das ringförmige Gebilde zusätzlich eine Radialausdehnung mit Bezug auf die Außenfläche aufweist, derart, dass die Radialausdehnung (C, C' C", oder C") hiervon größer als die Ringgebildebreite ist.

4. Einrichtung nach Anspruch 3, wobei das ringförmige Gebilde eine im wesentlichen rechteckige Form hat, wobei die Ringgebildebreite (B bzw. B') und die Radialausdehnung (C bzw. C') benachbarte Seiten eines Rechtecks bilden.

5. Einrichtung nach Anspruch 3, wobei das ringförmige Gebilde eine im wesentlichen dreieckige Form hat, wobei die Ringgebildebreite (B" bzw. B"') die Basis des Dreiecks und die Radialausdehnung (C" bzw. C"') die Höhe des Dreiecks bilden.

6. Einrichtung nach einem der Ansprüche 3, 4 oder 5, wobei das ringförmige Gebilde eine Nut ist, und die Radialausdehnung (C bzw. C") in Bezug auf die Außenfläche einwärts gerichtet ist.

7. Einrichtung nach einem der Ansprüche 3, 4 oder 5, bei welcher das ringförmige Gebilde eine Rippe ist, deren Radialausdehnung (C' bzw. C"') mit Bezug auf die Außenfläche auswärts verläuft.

8. Einrichtung nach Anspruch 1, wobei die Abschirmkonstruktion elektrisch gegen Massepotential bzw. das Potential des mindestens einen Lagerblocks isoliert ist.

9. Einrichtung nach einem der vorhergehenden Ansprüche, wobei die mindestens eine zylindrisch geformte Abschirmkonstruktion einen von jedem der Lagerblöcke getragenen einheitlichen Schirm bildet, der einheitliche Schirm um einen Teil des Targetumfangs verläuft, der im wesentlichen außerhalb der Zerstäubungszone liegt, und eine Öffnung aufweist, die mindestens so groß wie die Zerstäubungszone ist, wobei die Öffnung sich über einen weiteren Teil des Umfangs erstreckt, der im wesentlichen innerhalb der Zerstäubungszone liegt und eine Länge hat, die kleiner als der Abstand zwischen

den beiderseitigen Enden des Targets ist.

10. Einrichtung nach Anspruch 1, wobei die mindestens eine zylindrisch geformte Abschirmkonstruktion erste und zweite zylindrische Schirme (38 und 40) umfaßt, die jeweils vom ersten bzw. zweiten Lagerblock der Lagerblöcke getragen wird.

11. Verfahren zum Aufbringen eines die elektrischen oder isolierenden Films auf ein Substrat in einer Einrichtung mit einer Vakuumkammer und einer gasförmigen Atmosphäre in dieser durch Zerstäuben von Material von einem zylindrisch geformten Target (14), das mit seinen entgegengesetzten Enden (42, 44) durch Lagerblöcke (16,18) drehbar gelagert ist und darin nicht drehbar gehalterte Magnete enthält, um eine Zerstäubungszone zu erzeugen, die entlang der Targetlänge verläuft, wobei die Einrichtung (10) eine elektrische Energiequelle (36) in elektrischer Verbindung mit dem Target und mindestens eine zylindrisch geformte Abschirmkonstruktion (38 und/oder 40) aufweist, die von mindestens einem der Lagerblöcke getragen wird und sich über mindestens das zugeordnete Targetende mit einem Zwischenraum (50) dazwischen erstreckt, **dadurch gekennzeichnet, dass** das Verfahren den Schritt des Unterbrechens der Bewegung irgendeines Lichtbogens (56) umfaßt, der sonst über eine Außenfläche (62) des Schirms wandern könnte, durch Verwendung mindestens eines ringförmigen Gebildes (52), das um die Außenfläche verläuft und zur Unterbrechung der Bewegung dimensioniert ist.

Revendications

1. Dispositif (10) pour déposer, dans une atmosphère gazeuse à l'intérieure d'une chambre à vide, une couche sur un substrat (22) par pulvérisation cathodique d'un matériau à partir d'une cible (14) de forme cylindrique qui est supportée en rotation à ses extrémités opposées (42, 44) par des blocs de support respectifs (16, 18), la cible contenant des aimants contenus dans celle-ci de façon non rotative de manière à établir une zone de pulvérisation s'étendant sur une longueur de la cible, le dispositif comprenant une alimentation électrique (36) en communication électrique avec la cible, et le dispositif comprenant au moins une structure-écran de forme cylindrique (38 et/ou 40), portée par au moins un des blocs de support et s'étendant au-dessus d'au moins une extrémité associée de la cible avec un espace libre (50) entre elles, ***caractérisé en ce que*** la structure-écran comprend au moins une structure annulaire (52) entourant une surface extérieure (62) de la structure-écran et dimensionnée de manière à interrompre le mouvement de tout arc (56) qui sans cela traverserait la surface extérieure.

2. Dispositif selon la Revendication 1, dans lequel la structure annulaire est dimensionnée de manière à interrompre la formation du plasma qui sans cela se produirait au voisinage de la structure annulaire.

3. Dispositif selon la Revendication 1 ou la Revendication 2, dans lequel ladite au moins une structure annulaire possède une largeur (B, B', B" ou B"') qui est inférieure à un demi trajet libre moyen du gaz dans la chambre à vide et supérieure à une largeur (D) de l'arc, la structure annulaire se projetant de plus radialement par rapport à la surface extérieure de telle sorte qu'une extension radiale (C, C', C" ou C"') de la structure annulaire soit supérieure à la largeur de la structure annulaire.

4. Dispositif selon la Revendication 3, dans lequel la structure annulaire est de forme essentiellement rectangulaire, la largeur de la structure annulaire (B ou B') et l'extension radiale (C ou C') formant des côtés adjacents d'un rectangle.

5. Dispositif selon la Revendication 3, dans lequel la structure annulaire est de forme essentiellement triangulaire, la largeur de la structure annulaire (B" ou B"') formant une base d'un triangle et l'extension radiale (C" ou C"') formant une hauteur du triangle.

6. Dispositif selon l'une quelconque des Revendications 3, 4 ou 5, dans lequel la structure annulaire est une rainure, l'extension radiale (C ou C") étant orientée vers l'intérieur par rapport à la surface extérieure.

7. Dispositif selon l'une quelconque des Revendications 3, 4 ou 5, dans lequel la structure annulaire est une nervure, l'extension radiale (C' ou C"') étant orientée vers l'extérieur par rapport à la surface extérieure.

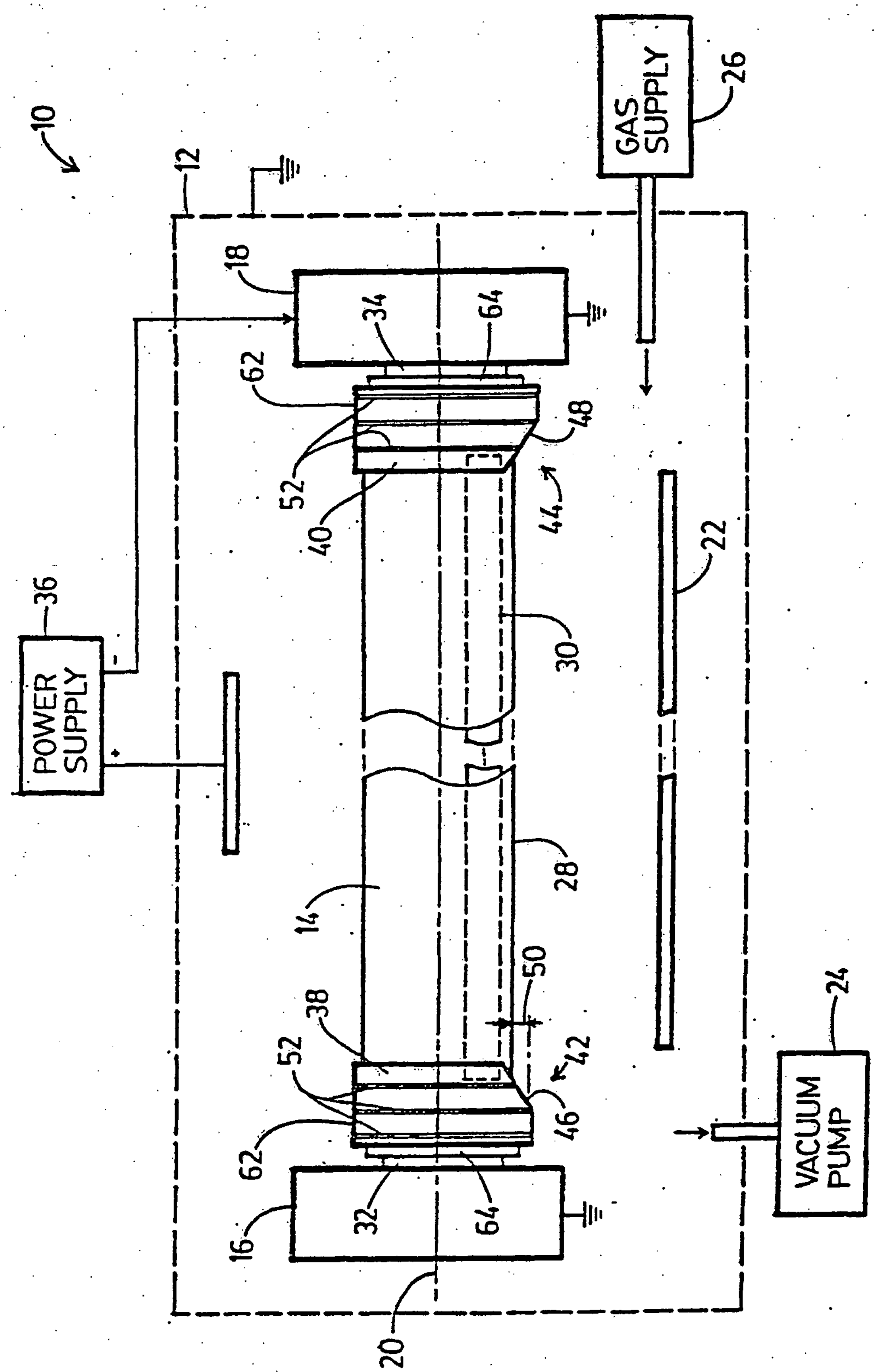
8. Dispositif selon la Revendication 1, dans lequel la structure-écran est isolée électriquement du potentiel de la terre ou d'un potentiel dudit au moins un bloc de support.

9. Dispositif selon l'une quelconque des Revendications précédentes, dans lequel ladite au moins une structure-écran de forme cylindrique comprend un écran unifié de forme cylindrique supporté par chacun des blocs de support, l'écran unifié s'étendant autour d'une portion d'une circonférence de la cible qui se trouve essentiellement à l'extérieur de la zone de pulvérisation, et ayant une ouverture au moins aussi grande que la zone de pulvérisation, l'ouveaure s'étendant autour d'une autre portion de la circonférence qui se trouve essentiellement à l'intérieur de la zone de pulvérisation et ayant une longueur inférieure à une distance entre les côtés op-

posés de la cible.

10. Dispositif selon la Revendication 1, dans lequel ladite au moins une structure-écran de forme cylindrique comprend un premier et un second écrans cylindriques (38 et 40) supportés respectivement par un premier et un second blocs de support des blocs de support.

11. Procédé de dépôt, dans un dispositif ayant une chambre à vide et une atmosphère gazeuse dans celle-ci, d'une couche diélectrique ou isolante sur un substrat par pulvérisation cathodique d'un matériau à partir d'une cible (14) de forme cylindrique qui est supportée en rotation à ses extrémités opposées (42, 44) par des blocs de support respectifs (16, 18), la cible contenant des aimants contenus dans celle-ci de façon non rotative de manière à établir une zone de pulvérisation s'étendant sur une longueur de la cible, le dispositif (10) comprenant une alimentation électrique (36) en communication électrique avec la cible, et le dispositif comprenant au moins une structure-écran de forme cylindrique (38 et/ou 40), portée par au moins un des blocs de support et s'étendant au-dessus d'au moins une extrémité associée de la cible avec un espace libre (50) entre elles, ***caractérisé en ce que*** le procédé comprend une étape d'interruption du mouvement de tout arc (56) qui sans cela traverserait une surface extérieure (62) de la structure-écran, par utilisation d'au moins une structure annulaire (52) entourant la surface extérieure et dimensionnée de manière à interrompre le mouvement.


10
12
GAS SUPPLY
26
18
34
64
62
48
52
40
44
22
36
POWER SUPPLY
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46
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VACUUM PUMP
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32
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FIG._1.

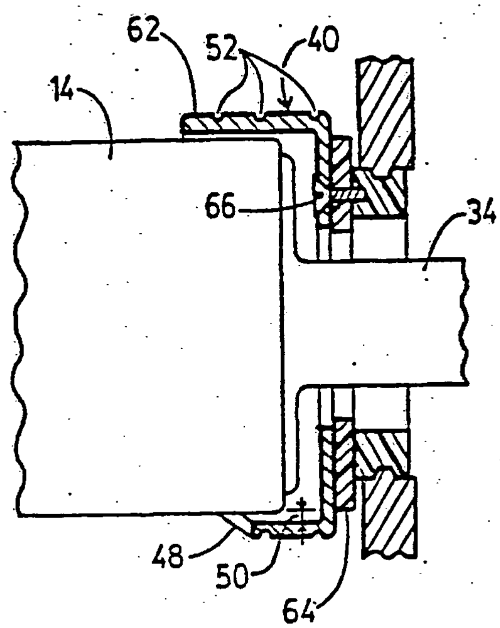

FIG._2.

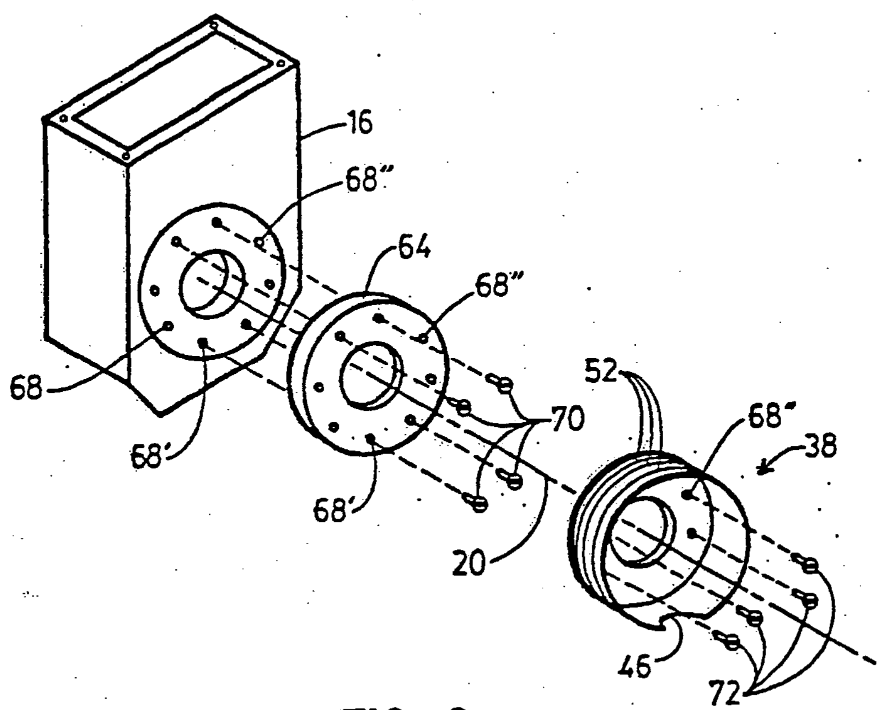

FIG._3.

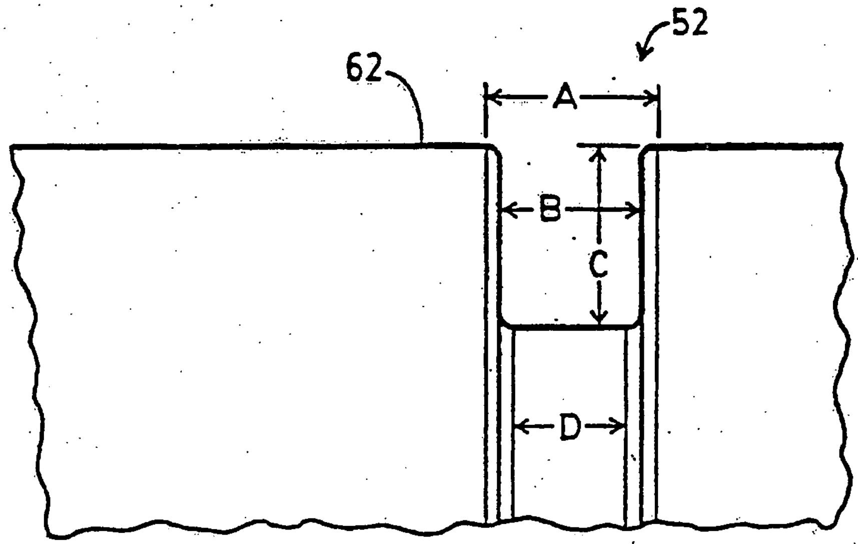

FIG._4.

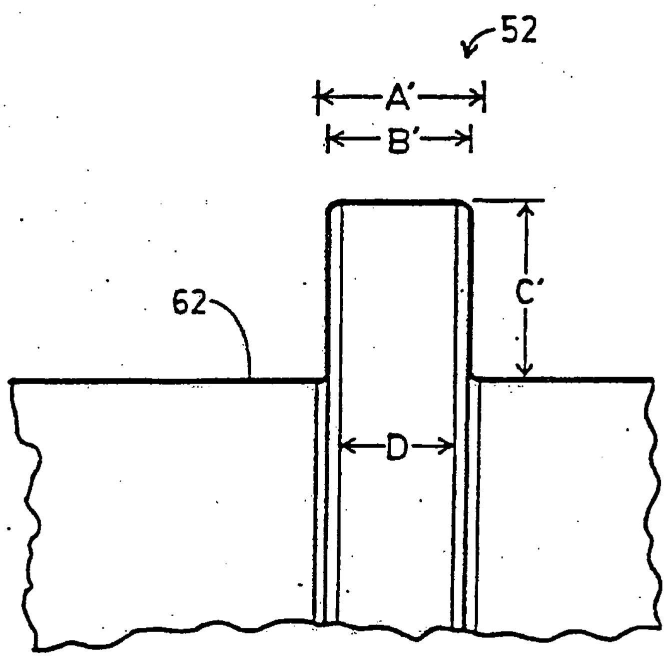

FIG._5.

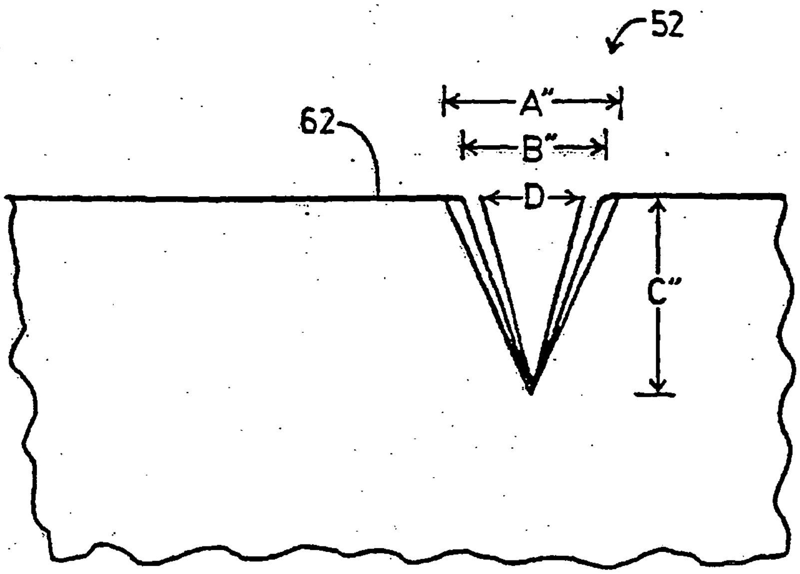

FIG._6.

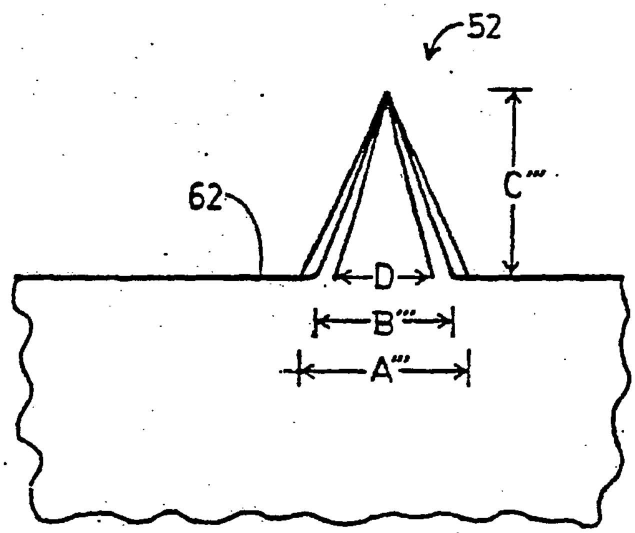

FIG._7.

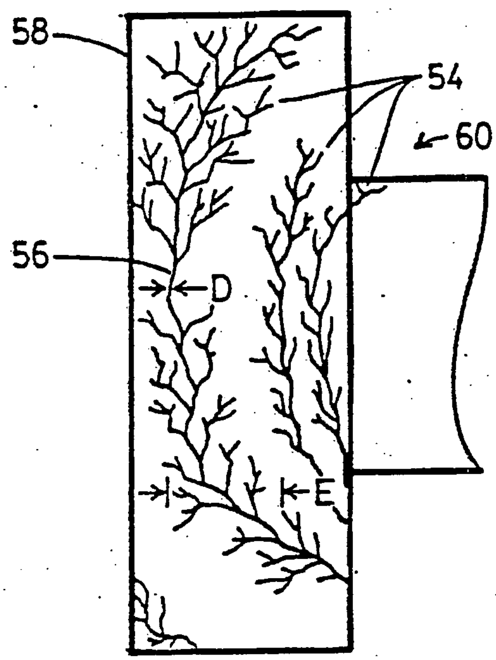

FIG._8.